New Series, VI.

DOVE MARINE LABORATORY,

Cullercoats, Northumberland.

REPORT

For the Year ending 30th June, 1917.

Edited by ALEXANDER MEEK,

Professor of Zoology, Armstrong College, in the University of Durham,

and

Director of the Dove Marine Laboratory.

Published by the Marine Laboratory Committee of Armstrong College on behalf of the Northumberland Sea Fisheries Committee and other contributing authorities.

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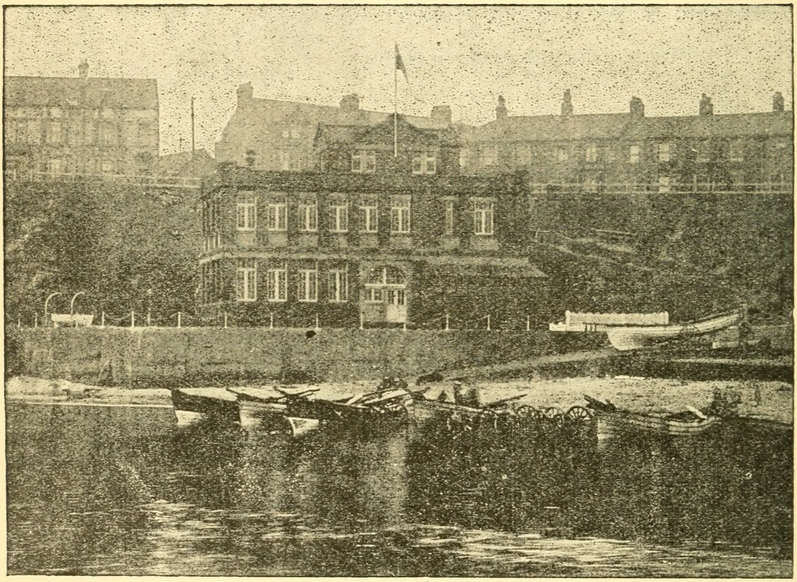


Dove Marine Laboratory, Cullercoats.

SUMMARY AND GENERAL REPORT.

This Report does not give a full account of the activities of the year. It will be noted that we have been able to carry on some of the important investigations, but others have had to be suspended owing to the continued absence of the Naturalist, Mr. B. Storrow.

Herring fishing with drift nets took place from a number of the ports of the north-east coast last summer, and we therefore had the opportunity of examining samples from different parts of the district. The samples, which totalled over 3,000 herrings, and belonged to the Northumberland school, were dealt with in the early part of the season by Mr. Storrow, and the work was continued by Miss Stone. The results proved to be very interesting. Hitherto the Northumberland herring have consistently presented a predominance of the three-winter group. Last summer this group was predominant at the beginning of the season, but gave place in July to the next year group, and later the spawning shoal entered the northern part of the district, and spawning took place in the Longstone area. A sample of the Forth winter spawning herring was also examined, and in connexion therewith a table is given showing the comparative analysis of the straight line relationship of the measurements of this race with the Northumberland and the Dogger Bank schools of summer herring. Many post-larval herring were found to have been destroyed in the Tyne at Newcastle in May, and it is highly probable that these young herring were derived from the Firth of Forth.

The experiments in mussel culture at Fenham Flats, Holy Island, were, as has been indicated in previous reports, so far successful as to warrant our advising the Northumberland Sea Fisheries Committee to take steps to form a mussel bed there, sufficiently large at least to supply the district. The Committee are willing to enter upon an undertaking of this kind, but legal difficulties have intervened, and at the moment some other method appears to be necessary, and will likely be adopted. A report of a sub-committee appointed to inspect the bed is given. The general question of the fate of the larval stage is discussed, the conclusion being that usually each region where mussels are cultivated or are naturally deposited obtains its spat from places on the current side of the position.

In previous reports we have drawn attention to the serious nature of the pollution of the Tyne in the neighbourhood of Newcastle. This year in May a spell of dry weather made the Tyne so poisonous that descending kelts and smolts were destroyed, and even sea fish in the young condition which had been drifted up the river. It is suggested that a scheme of town planning in Newcastle and Gateshead should include the cleaning of the river by all concerned. The manufacturers and the cities should take steps to treat the effluents so as to render them innocuous before they are poured into the river.

Miss O. M. Jorgensen, B.Sc., Research Student, in spite of the fact that her time was taken up to a large extent as Demonstrator in Zoology, carried on a research on the early stages of development of the common shore sponge, *Grantia compressa*. She has come to the conclusion, like Dendy and others, that

the germ cells arise from the choanocytes, that these are the essential sponge elements, and that the sponge may be regarded as a colony of Choanoflagellate Protozoa.

A general paper is given on the Phoronidea, in which the attempt is made to associate *Phoronis ovalis* and *Actinotrocha branchiata* as one species, to indicate the general relationships of the adult and larval species of the group, to present the essential features of development, metamorphosis and structure, and to discuss the position of the group.

The Tyne, at all events the North Tyne, and its tributary, the Reed, are rich in larval lampreys, but the adults are seldom seen. An account is given of the many larvae which have been collected at Houxty and in the neighbourhood of Bellingham, and attention is directed to the fact that although the larvae are so common, the efforts made to secure or even to see the adults have thus far been unsuccessful.

It is acknowledged that at the limits of distribution hydrographical conditions are important, and it has been suggested that in the area of distribution hydrographical and food conditions are factors influencing migrations. As I stated in my work on the "Migrations of Fish," I did not find it necessary to introduce such considerations apart from ocean currents. A short discussion of the question is given with a view to indicating that these do not play an important part within the regions of distribution.

It is with sincere regret that we record here the death, on 27th November, 1916, of Mr. George Wilkinson. He was Clerk to the Northumberland Sea Fisheries Committee since its forma-

tion in March, 1890. He was greatly interested in the work of the Committee, and also in the practical fishery questions which were investigated at the Marine Laboratory. He gave a great deal of help when the first Laboratory was instituted at Cullercoats, and especially when acting as co-secretary at the time that the present Laboratory was built.

A. MEEK.

July 12th, 1917.

HERRING INVESTIGATIONS.—FIGURE I.

HERRING INVESTIGATION, 1916-17.

By A. MEEK and DOROTHY STONE.

During the herring season of 1916 we were able to examine samples from several ports in the Northumberland district, and, as will be seen from Table I., the samples totalled over 3,000 herrings. We found it possible also early in 1917 to analyse a sample of 250 of the Firth of Forth herring. It is a pleasure to us to acknowledge the help we have received from Mr. David Millar, Fishcurer, of North Shields. The samples obtained of the herrings landed at North Shields were examined in Mr. Millar's curing house, and he gave us every facility in the work. Before Mr. Storrow was called up to join the Navy, he was able to visit Berwick, Seahouses and Hartlepool, and the samples obtained at the end of June and the beginning of July from these places were dealt with by him. Mr. Storrow was received with great kindness and consideration at these places, and was helped materially by Messrs. R. Holmes and Sons, and Messrs. Craig & Co., Berwick; Messrs. C. & R. Dawson, Seahouses; and Mr. Guthrie, Hartlepool.

We also take this opportunity of acknowledging with thanks the help given by Miss Jorgensen in examining some of the samples of scales.

The samples examined at the several ports were taken at random, and in the case of those that were sent, instructions were given not to make any attempt at selection. The general nature of the samples will be seen in Table I., and the localities of capture are indicated in Figure 1 (Chart).

Size and Age.—In the absence of Mr. Storrow it is not deemed desirable to do more than refer to some of the outstanding results of the present investigations. These will be of much more value when they are correlated with our previous work, but it is only fair that as Mr. Storrow has done the work up to now he should have the opportunity of reviewing it more completely when he returns.

The most interesting and striking feature of the analysis for 1916 is the demonstration of the presence in large numbers during

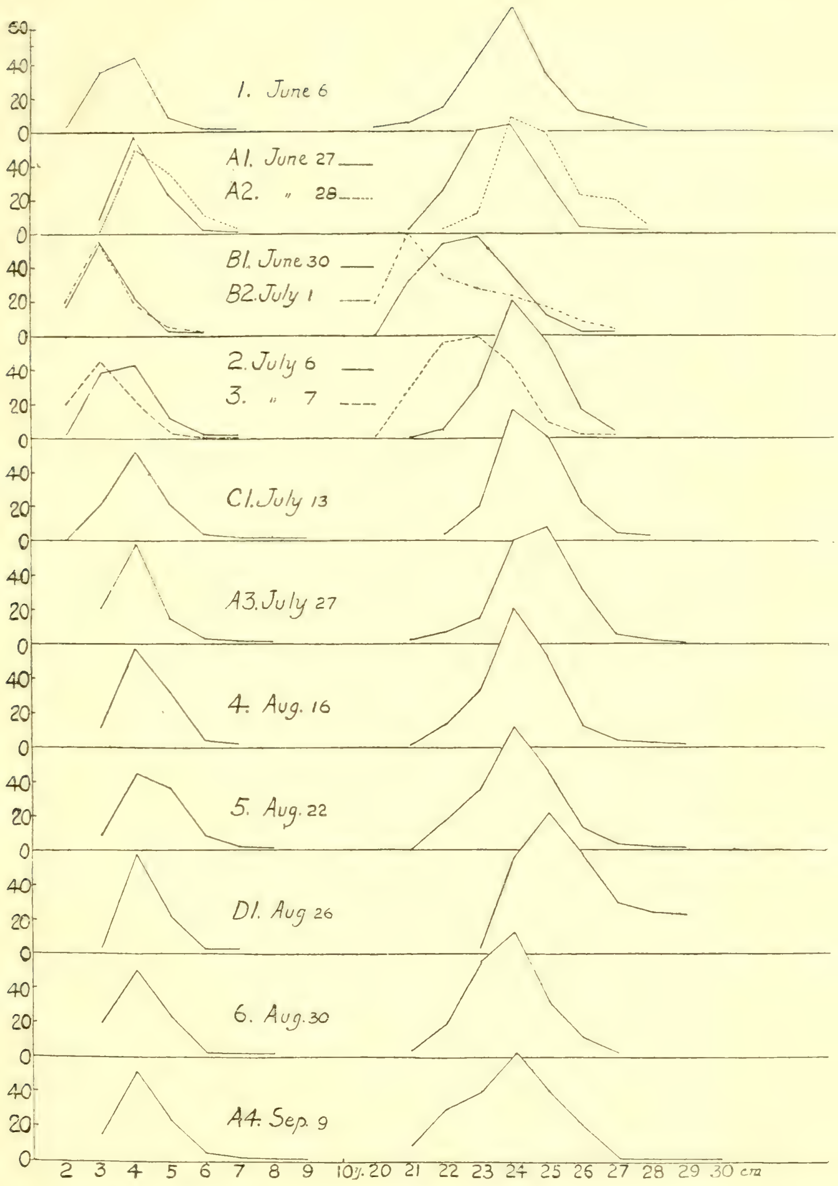
the greater part of the season of herring with four winter-rings. As has been apparent from the reports of our previous work, there has been practically no exception to our district presenting a predominancy of herring with three winter-rings. From Tables II. and IV. and Figure 2 it will be seen that three winter-ring herring were present on the coast in numbers in June, except at the extreme north end of the district—samples A1 and A2. In July, the four winter-ring herring became predominant, and characterised the catches for the remainder of the season. The herring in question were all caught by drift nets off the Northumberland coast. The year 1916 was abnormal in that the herring caught were for the most part a year older than those obtained during the years 1912-1915 (*see* last report).

This feature is illustrated also in Table III. and Figure 2, when the results are considered with reference to size. The smaller, and as has been shown, the younger herring, occupied the region in the early part of the season, and gave place in the first fortnight of July to the next year group.

The herring therefore appear to enter our region from the north, for in this abnormal season we see the gradual disappearance of the three winter ring group and the appearance in the northern part of the district of the four winter ring group, which this year for some reason seems to have advanced further south than usual.

In Figure 1 we have indicated the regions in which it was found that herring spawning had taken place as determined by the capture of "spawny" haddocks. The information was furnished by Mr. L. Collins, the Board's Collector of Fishery Statistics at North Shields, and is given below in tabular form :—

	Cwts.	Locality.
August 28th	110	10 miles E.N.E. of the Longstone.
September 2nd ...	178	38 miles E.N.E. of the May Light.
,, 4th ...	159	10 miles N.E. of the Longstone.
,, 4th ...	133	10 miles N.E. by N. of the Longstone.
,, 6th ...	87	11 miles N.E. by E. ½ E. of the Longstone.
,, 6th ...	91	8 miles N.E. by E. of the Longstone.
,, 11th ...	73	11 miles N.E. by E. ½ E. of the Longstone.
,, 25th ...	205	50 miles N.E. ½ E. of Tyne.
,, 26th ...	235	50 miles N.E. ½ E. of Tyne.



HERRING INVESTIGATIONS.—FIGURE II.

From this table and the chart it is evident that spawning took place in at least three areas, and all may be said to affect our district. The principal one for the Northumberland region is that to the north east of the Longstone. From general notes that were made of the samples examined even up to September it appears that the herring of the region were on the whole not quite mature. It is thus evident that the mature herring which spawned to the north-east of the Longstone at the end of August and the early part of September represented a third wave of migrants, in this case of the mature shoal of the Northumberland school.

There was one exception to the statement made above as to the maturity of the samples. About a fourth of the herring of sample D1 were found to be ready for spawning, but we have no record of spawning having taken place in the region from which D1 was obtained. A letter from Mr. R. Dawson, Seahouses, received on September 19th, showed that the few herrings landed at Seahouses at that period when stormy weather was experienced were "full." These herring were obtained in the region of D1, and it is probable therefore that the spawning ground is more extensive, as we have found from previous records of "spawny" haddocks than is given in Figure 1.

The young herring drifted up the Tyne by the tide and poisoned by the effluents in the Newcastle region (this Report, page 25) are interesting in this connexion. They were obtained in May, and if they came from last year's autumn spawning they would be about nine months old. Even the larger of the series reported in the paper on "Pollution of the Tyne" appear to be younger than that, and at all events the smaller group cannot be referred to this spawning time and place. From their condition and size they may be concluded to have been derived from a winter spawner, and the only winter spawning region therefore to which they can be related is the Firth of Forth. This goes to indicate the length of the denatation of the "O" group.

There were last year no trawl herring available, and we are thus unable to say anything with regard to them.

The sample from the Firth of Forth (E1) is as one should expect very different in age composition from the summer herring of the Northumberland coast. It includes four to nine winter-ring groups, and all are evidently mature herring of five to ten years. They present an interesting and noteworthy diminishing series of numbers according to age.

A portion of this sample was measured in detail with a view to indicating racial character. As was shown in the report (New Series, 111) for 1913-14, the measurements resolved themselves into straight lines when expressed with relation to length. In the original table in that report the various measurements were referred to the length of the scale covered portion of the body, but as the total length has been adopted for other fishes and is more generally employed the opportunity has been taken in Table V. to express the measurements made in 1913 in terms of total length, together with the sample from the Firth of Forth obtained this year (1917). It will be at once clear that the sample differs from both the trawl and the drift net herring of the Northumberland coast with reference to the position of the pelvic, ventral (anal) and the dorsal fins. It is also plain that the suggestion that the sample of 1914 got so far out early in the season of that year belonged to the Firth of Forth school was wrong. The sample proved (Report, New Series, IV.) to include herrings of two to nine winter rings, with four to five winter rings predominating, and evidently belonged to one of the summer spawners.

TABLE I.

Sample.	No. in Sample.	Date.	Locality.
1 (North Shields) ...	252	6th June ...	25 miles N.N.E. of Tyne.
2 ,, ...	250	6th July ...	25 miles E.S.E. of Tyne.
3 ,, ...	200	7th July ...	22 miles S.E. by E. ½ E. of Tyne.
4 ,, ...	200	16th August ...	20 miles E. by N. of Tyne.
5 ,, ...	200	22nd August ...	25 miles S.E. of Tyne.
6 ,, ...	250	30th August ...	20 miles E. by N. of Hartlepool.
A1 (Berwick) ...	250	27th June ...	14 miles S.E. of Berwick.
A2 ,, ...	200	28th June ...	14 miles S.E. by E. of Berwick.
A3 ,, ...	200	27th July ...	25 miles S.S.E. of Berwick.
A4 ,, ...	250	9th September	25 miles S.E. of Berwick.
B1 (Seahouses) ...	250	30th June ...	13 miles E. by S. of Seahouses.
B2 ,, ...	200	1st July ...	13 mi;es E. by S. of Seahouses.
C1 (Hartlepool) ...	220	13th July ...	12 miles E. by N. of Hartlepool.
D1 (Craster)	250	26th August ...	12 miles E. from Craster.
E1 (Firth of Forth) ...	250	1st Feb., 1917 ...	Portobello Bart—between Prestonpans and Musselburgh.

TABLE II.—SIZE AND AGE.

CENTIMETRES.

Sample.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	Total.
1	2	2	2	5	3	—	—	—	—	—	—	12
	3	—	4	9	31	43	6	—	—	—	—	93
	4	—	—	4	22	49	34	6	2	1	—	118
	5	—	—	—	—	5	4	9	7	—	—	25
	6	—	—	—	—	—	—	—	1	—	—	1
	7	—	—	—	—	—	—	—	2	—	—	2
		2	6	18	56	97	44	15	12	1	—	251
2	2	—	1	2	4	1	—	—	—	—	—	8
	3	—	—	5	30	48	15	—	—	—	—	98
	4	—	—	—	7	43	41	9	1	—	—	101
	5	—	—	—	1	8	11	11	2	—	—	33
	6	—	—	—	—	—	4	1	3	—	—	8
	7	—	—	—	—	—	—	—	2	—	—	2
		—	1	7	42	100	71	21	8	—	—	250
3	2	2	20	18	2	1	—	—	—	—	—	43
	3	1	10	29	33	14	2	—	—	—	—	89
	4	1	1	6	16	24	1	1	—	—	—	50
	5	—	—	—	5	3	4	1	—	—	—	13
	6	—	—	—	1	—	—	1	1	—	—	3
	7	—	—	—	—	—	—	—	1	—	—	1
		4	31	53	57	42	7	3	2	—	—	199
4	3	—	—	4	8	7	3	—	—	—	—	22
	4	—	1	5	18	51	27	4	—	2	—	108
	5	—	—	1	7	23	21	6	2	—	—	60
	6	—	—	—	—	—	2	2	2	1	—	7
	7	—	—	—	—	—	—	—	1	—	—	1
	10	—	—	—	—	—	—	—	—	—	1	1
		—	1	10	33	81	53	12	5	3	1	199

TABLE II.—SIZE AND AGE.

CENTIMETRES.

Sample.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	Total.
5	3	—	1	7	6	1	—	1	—	—	—	16
	4	—	—	6	15	42	17	3	1	1	1	86
	5	—	—	3	12	24	27	5	—	2	—	73
	6	—	—	1	3	5	4	4	1	—	1	19
	7	—	—	—	—	2	—	1	—	1	—	4
	8	—	—	—	—	—	—	—	1	—	1	2
		—	1	17	36	74	48	14	3	4	3	200
6	3	—	5	19	13	10	2	1	—	—	—	50
	4	—	1	5	42	56	13	7	1	—	—	125
	5	—	—	—	11	24	23	5	—	—	—	63
	6	—	—	—	—	1	2	3	—	—	—	6
	7	—	—	—	1	—	—	—	1	—	—	2
	8	—	—	—	—	—	—	—	—	—	1	1
		—	6	24	67	91	40	16	2	—	1	247
A 1	3	—	2	7	10	8	—	—	—	—	—	27
	4	—	5	21	51	46	19	1	1	—	—	144
	5	—	—	2	13	22	21	5	2	—	—	65
	6	—	—	—	1	2	3	2	1	—	—	9
	7	—	—	—	—	—	—	—	1	2	—	3
		—	7	30	75	78	43	8	5	2	—	248
A 2	3	—	—	1	—	1	—	—	—	—	—	2
	4	—	—	4	10	47	26	10	2	—	—	99
	5	—	—	—	4	22	33	8	3	—	—	70
	6	—	—	—	—	—	3	5	12	2	—	22
	7	—	—	—	—	—	—	—	3	4	—	7
		—	—	5	14	70	62	23	20	6	—	200

TABLE II.—SIZE AND AGE.

CENTIMETRES.

Sample.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	30	Total.
A3	3	—	3	5	8	11	9	3	—	—	—	—	39
	4	—	1	3	6	40	48	17	2	—	—	—	117
	5	—	—	—	—	9	11	7	4	—	—	—	31
	6	—	—	—	—	1	—	3	3	2	—	—	9
	7	—	—	—	—	—	—	—	—	1	2	—	3
	8	—	—	—	—	—	—	—	—	1	—	—	1
		—	4	8	14	61	63	30	9	4	2	—	200
A4	3	—	3	12	13	10	3	1	—	—	—	—	42
	4	—	—	9	19	53	30	12	2	—	—	—	125
	5	—	—	4	5	11	20	18	6	—	—	—	64
	6	—	—	—	2	3	—	6	1	—	1	—	13
	7	—	—	—	—	1	—	2	1	—	—	—	4
	8	—	—	—	—	—	—	—	1	—	—	—	1
	9	—	—	—	—	—	—	—	—	—	—	1	1
		—	3	25	39	78	53	39	11	—	1	1	250
B1	2	3	27	16	—	1	—	—	—	—	—	—	47
	3	1	8	46	54	25	4	1	—	—	—	—	139
	4	—	5	6	13	19	10	2	1	—	—	—	56
	5	—	—	—	1	2	2	—	1	—	—	—	6
	6	—	—	—	—	—	1	—	1	—	—	—	2
		4	40	68	68	47	17	3	3	—	—	—	250
B2	2	12	23	4	—	—	—	—	—	—	—	—	39
	3	8	35	25	23	13	6	1	—	—	—	—	111
	4	—	1	6	7	13	8	5	1	—	—	—	41
	5	—	—	—	1	3	2	2	..	—	—	—	8
	7	—	—	—	—	—	—	1	—	—	—	—	1
		20	59	35	31	29	16	9	1	—	—	—	200

TABLE II.—SIZE AND AGE.

CENTIMETRES.

Sample.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	30	Total.
C1	2	—	—	1	—	—	—	—	—	—	—	—	1
	3	—	—	4	12	22	5	2	—	—	—	—	45
	4	—	—	2	8	52	45	7	1	—	—	—	115
	5	—	—	—	3	8	17	14	2	1	—	—	45
	6	—	—	—	1	1	1	4	2	—	—	—	9
	7	—	—	—	—	—	—	—	2	—	—	—	2
	8	—	—	—	—	—	—	1	—	—	—	—	1
	9	—	—	—	—	—	—	—	1	—	—	—	1
		—	—	7	24	83	68	28	8	1	—	—	219
D1	3	—	—	—	—	14	15	1	—	—	—	—	30
	4	—	—	—	8	37	65	28	4	—	—	—	142
	5	—	—	—	1	19	21	15	3	2	1	—	62
	6	—	—	—	—	2	1	2	3	1	1	—	10
	7	—	—	—	—	—	—	1	1	1	1	—	4
		—	—	—	9	72	102	47	11	4	3	—	248
E1	4	—	3	5	8	18	32	15	10	3	—	—	94
	5	—	—	5	3	14	16	15	21	14	3	—	91
	6	—	—	1	1	1	2	4	8	14	10	1	42
	7	—	—	—	—	—	1	1	—	8	3	1	14
	8	—	—	—	—	—	—	—	2	4	—	—	6
	9	—	—	—	—	—	—	—	—	—	—	1	1
		—	3	11	12	33	51	35	41	43	16	3	248

TABLE III.—SIZE.

CENTIMETRES.

Sample.		20	21	22	23	24	25	26	27	28	29	30
1	Nos. ...	2	6	17	56	97	44	15	12	1	—	—
	% ...	0·8	2·4	7·2	22·3	38·2	17·5	5·9	4·8	0·4	—	—
2	Nos. ...	—	1	7	42	100	71	21	8	—	—	—
	% ...	—	0·4	2·8	16·8	40·0	28·4	8·4	3·2	—	—	—
3	Nos. ...	4	31	53	57	42	7	3	2	—	—	—
	% ...	2	15·6	26·6	28·6	21·1	3·5	1·5	1·0	—	—	—
4	Nos ...	—	1	10	33	81	53	12	5	3	1	—
	% ...	—	0·5	5·0	16·6	40·7	26·6	6·0	2·5	1·5	0·5	—
5	Nos. ...	—	1	17	36	74	48	14	3	4	3	—
	% ...	—	0·5	8·5	18·0	37·0	24·0	7·0	1·5	2·0	1·5	—
6	Nos. ...	—	6	24	67	91	40	16	2	—	1	—
	% ...	—	2·5	9·7	27·1	36·8	16·2	6·4	0·8	—	0·4	—
A1	Nos. ...	—	7	30	75	78	43	8	5	2	—	—
	% ...	—	2·8	12·1	30·2	31·4	17·3	3·2	2·0	0·8	—	—
A2	Nos. ...	—	—	5	14	70	62	23	20	6	—	—
	% ...	—	—	2·5	7·0	35·0	31·0	11·5	10·0	3·0	—	—
A3	Nos. ...	—	4	8	14	61	68	30	9	4	2	—
	% ...	—	2·0	4·0	7·0	30·5	34·0	15·0	4·5	2·0	1·0	—
A4	Nos. ...	—	3	25	39	78	53	39	11	—	1	1
	% ...	—	1·2	10·0	15·6	31·2	21·2	15·6	4·4	—	0·4	0·4
B1	Nos ...	4	40	68	68	47	17	3	3	—	—	—
	% ...	1·6	16·0	27·2	27·2	18·8	6·8	1·2	1·2	—	—	—
B2	Nos. ...	20	59	35	31	29	16	9	1	—	—	—
	% ...	10·0	29·5	17·5	15·5	14·5	8·0	4·5	0·5	—	—	—
C1	Nos. ...	—	—	7	24	83	68	28	8	1	—	—
	% ...	—	—	3·2	10·9	37·9	31·1	12·8	3·6	0·5	—	—
D1	Nos. ...	—	—	—	9	72	102	47	11	4	3	—
	% ...	—	—	—	3·6	29·0	41·1	18·9	4·4	1·7	1·2	—
E1	Nos. ...	—	3	11	12	33	51	35	41	43	16	3
	% ...	—	1·3	4·4	4·8	13·2	21·1	14·1	16·5	17·3	6·5	1·3

TABLE IV.—AGE.

WINTER RINGS.

Sample.		2	3	4	5	6	7	8	9	10
1	Nos. ...	12	92	118	25	1	2	—	—	—
	% ...	4·8	37·1	47·0	9·9	0·4	0·8	—	—	—
2	Nos. ...	8	98	101	33	8	2	—	—	—
	% ...	3·2	39·2	40·4	13·2	3·2	0·8	—	—	—
3	Nos. ...	43	89	50	13	3	1	—	—	—
	% ...	21·6	44·7	25·1	6·5	1·5	0·5	—	—	—
4	Nos. ...	—	22	108	64	7	1	—	—	1
	% ...	—	11·1	54·3	30·2	3·5	0·5	—	—	0·5
5	Nos. ...	—	16	86	73	19	4	2	—	—
	% ...	—	8·0	43·0	36·5	9·5	2·0	1·0	—	—
6	Nos. ...	—	50	125	63	6	2	1	—	—
	% ...	—	20·2	51·0	25·6	2·4	0·8	0·4	—	—
A1	Nos. ...	—	27	144	65	9	3	—	—	—
	% ...	—	10·9	58·1	26·2	3·6	1·2	—	—	—
A2	Nos. ...	—	2	99	70	22	7	—	—	—
	% ...	—	1·0	49·5	35·0	11·0	3·5	—	—	—
A3	Nos. ...	—	39	117	31	9	3	1	—	—
	% ...	—	19·5	58·5	15·5	4·5	1·5	0·5	—	—
A4	Nos. ...	—	42	125	64	13	4	1	1	—
	% ...	—	16·8	50·0	25·6	5·2	1·6	0·4	0·4	—
B1	Nos. ...	47	139	56	6	2	—	—	—	—
	% ...	18·8	55·6	22·4	2·4	0·8	—	—	—	—
B2	Nos. ...	39	111	41	8	—	1	—	—	—
	% ...	19·5	55·5	20·5	4·0	—	0·5	—	—	—
C1	Nos. ...	1	45	115	45	9	2	1	1	—
	% ...	0·5	20·6	52·5	20·6	4·1	1·0	0·5	0·5	—
D1	Nos. ...	—	30	142	62	10	4	—	—	—
	% ...	—	12·1	57·2	25·0	4·0	1·7	—	—	—
E1	Nos ...	—	—	94	91	42	14	6	1	—
	% ...	—	—	37·9	36·7	16·9	5·6	2·4	0·4	—

TABLE V.—DRIFT NET.

		Head.	Pelvic.	Ventral.	Dorsal.	
					Ant.	Post.
1911—Yarmouth ...	...	·19	·470	·664	·439	·539
1912—North Shields ...	...	·19	·467	·669	·439	·540
1913—North Sunderland	...	·19	·474	·677	·442	·547
1913—North Shields ...	F	·19	·474	·677	·442	·547
	M	·19	·474	·677	·442	·547
	F	·19	·474	·677	·442	·540
	M	·19	·477	·682	·445	·544
1914—100 miles E. ...	...	·19	·470	·671	·451	·560
1917—Firth of Forth ...	...	·19	457	·650	·437	·567

TRAWL.

1911—North Shields ...	...	·19	·467	·672	·441	·545
1912— „ ...	...	·19	·470	·677	·445	·549
1913— „	F	·19	·467	·674	441	·545
	M	·19	·467	·677	·439	545
	F	·19	·467	·674	·441	·545
	M	·19	·464	·674	·439	·544
	F	·19	·468	·674	·439	·544
	M	·18	·470	677	·441	·544

THE PROBLEM OF MUSSEL CULTURE.

By A. MEEK.

The experiments which have been made at Fenham Flats have demonstrated that the mussels naturally settle in places where they do not grow satisfactorily, and that when the mussels are transplanted to the Scaup they rapidly reach a bait size. The larger mussels thus transplanted are ready for use in a year, and the smaller ones in two years.

At the present time there are five plots on the Scaup which were laid down by the Holy Island fishermen in accordance with an arrangement made last year. One of the plots was formed in July and the rest in September, 1916. They were inspected by Sir Francis Walker and Col. A. Marshall on behalf of the Northumberland Sea Fisheries Committee on November 27th, and the following report of the visit was presented at the April quarterly meeting :—

"We visited the mussel scaup at Fenham Flats on Monday, November 27th, and inspected the bed which had been formed by five of the Holy Island fishermen. These beds were made by arrangement by transplanting mussels naturally deposited higher up the Flats on the Scaup. One of the plots was formed in July and the rest in September.

"The visit indicated :—

1. "That there is a large area available for mussel cultivation.
2. "That the mussels grow rapidly after transplantation.
3. "That Fenham Flats being free from sewage contamination offers an excellent opportunity, if more mussels than are required for bait are cultivated, of supplying the markets with a reliable mussel for human consumption.

"The method of cultivation which is likely, at least to begin with, to be most satisfactory, is a simple one. Spat settles at

places easy of access from the Scaup, and all that is necessary is to move the young mussels periodically from the regions where they do not grow to the Scaup where they rapidly reach bait size and maturity. The supply on the Scaup thus formed by transplantation may be cropped as completely as may be found to be necessary without detriment.

"We calculate that the fishermen of the Northumberland district require rather more than 500 tons of mussels each year, and this could be supplied at say £2 per ton. But the aim ought to be to increase the supply to a greater extent than is demanded by the district. Possibly a profit could be derived from the regulation of the other shellfish of the area, especially cockles and periwinkles.

"We recommend therefore that the ground should be leased for twenty years by the Committee for the purpose of the cultivation of shellfish, and that the necessary arrangements for transplantation and subsequent distribution be entered into with as little delay as possible.

"The mussel scaup is a large one, and could easily and in a short period be made to bear a heavy crop of mussels. Its isolation from the railway is at once a drawback and an advantage, for supervision is thereby reduced to a minimum. We have to choose between overcoming the difficulties of land transport and adopting a scheme for sea transport. We recommend the latter. The fishermen of the northern part of the district may find it convenient to go to the Scaup in their own boats for their supplies. But for the purpose of taking mussels to Seahouses for putting on the railway and for the work of transplantation we recommend that a flat boat of the shape of a salmon coble, measuring say 20 feet, with a beam of say 5 feet, and provided with a small motor—5 horse-power—altogether costing about £100, should be obtained. A boat of this size would be able to carry a load of 2 tons, and thus during the favourable part of the year large quantities of young mussels could be transplanted, and the produce of the beds could be run as required to Seahouses.

"Holy Island is the only village near to the Scaup, and for labour and supervision we should naturally look to that place. One man would have to be permanently employed, and for convenience ought to be housed in the house at present available on

the Old Law—a house which overlooks the Scaup. Other help would be obtainable at Holy Island as and when required.

"At present the Holy Island fishermen pay a small sum annually for leave to use the mussels to the Earl of Tankerville. These rents ought to be taken over, and arrangements made with the fishermen for the supply on mutually convenient terms, on the understanding also that the fishermen will help in looking after the beds. It would be necessary also to regulate the gathering of the other shellfish by the fishermen, so that the mussel scaup or that portion of it under mussels would not be interfered with.

"It might be necessary and desirable to get a local farmer to stir up the ground on a part of the Scaup with a grubber so as to remove the sand and prepare a better bed for the transplanted mussels.

"We hope that the preliminaries will be settled in time to make a start this season."

From experiments which have been made in the quiet conditions of tanks it has been demonstrated that the larvae of the mussels become planktonic in some twelve to twenty hours after the fertilization of the egg. It has also been shown by such experiments, as those by Scott, that the larvae are planktonic for about four days. An experiment of this kind at Cullercoats confirmed this conclusion, for the larvae remained planktonic for four days, and the pelagic state was retained in many cases up to eight days. Practically the whole of the area at Holy Island is uncovered by the ebb tide, the water being carried mainly through the narrow channel between the Beacons and Holy Island into Skate Roads, where it joins the ebb current leading outwards in the direction of Emmanuel Head. Thus after an ebb tide, the larvae, which have become free when the slake is covered with water, will be carried away from the slake, only a small proportion remaining in the channel and harbour. During a free period of say four days even they will have time to be transported some distance to the south. The mussel, however, is widely spread round our coasts, and in certain regions as at the mouths of rivers and such flats as we are now considering it occurs in large numbers. As the result of spawning which takes place from say April to July, and may be continued into the autumn, myriads of larvae are liberated in coastal waters. In most places then it may be

presumed that the settling of the larvae is not due to the presence of mussels in one particular spot, but to the settling of spat, drifted there from a place or places on the current side of the region. So far as the east coast of the British Islands is concerned it may be said that the larvae after a series of pulsations in the tidal currents are carried to the south.

McIntosh in particular has drawn attention to the immense number of young mussels in such an area as St. Andrews Bay during July and August. He further noted that when they settled on zoophytes and the like at the bottom, they had the power of detaching themselves and becoming planktonic. Depending on this and other variable circumstances, it is evident that the young mussels may be carried some distance along the coast before they settle down more or less completely. Their efforts are evidently circumscribed however, judging from the large numbers which attach themselves to rocks in situations where they only arrive at a stunted growth.

In such a region as Fenham Flats therefore, it is only right to keep in mind that however we may extend the resources of the area by transplantation we are not thereby increasing the local deposition of spat. Should we wish to retain spat from the Holy Island mussels it would be necessary to prepare a pond or ponds in which a selection of mature mussels could be placed each season, and in which the larvae could be retained until they settle down and make some progress in growth.

Larvae in plenty find their way into the region of the Flats, and the spat which settles in the regions above specified is ample for the requirements should it be decided to develop the area.

The mussel scaup at Holy Island is a large one, and at present beyond supporting a few cockles and periwinkles it may be said to be practically wasted. So far, however, the Committee is finding difficulty in obtaining the necessary powers to take over the area and devote it to the purpose of supplying shellfish and particularly mussels. I hope, however, to be able to report that the difficulties have been overcome, and that a mussel bed has been instituted on the lines indicated in this report.

POLLUTION OF THE TYNE.

By A. MEEK.

Northumbrians do not need to be reminded of the many beauties of the river to the west of the city, nor of the importance of the industries which occupy its banks from the city downwards. Most of them are aware also that the river above Newcastle continues to yield fishes native to its waters, and migratory fishes, or the more enterprising of them, which find their way from the sea. But it is perhaps only occasionally that they allow themselves to reflect that the growth of industries in the neighbourhood of Newcastle is threatening the exclusion of these migratory fish from the river.

It is known to the members of the Tyne Salmon Conservancy and to others who are familiar with the Tyne at Newcastle that every year many salmon are poisoned when they are attempting to pass Newcastle to gain the pure water above on the way to the spawning ground. The death rate is increased in dry seasons when the effluents are poured into a deep river which requires a great flow from above to dilute it sufficiently to give the migrants a chance of passing the region.

This year (1917) another serious aspect of the effects of the pollution at Newcastle was brought to my notice by the Laboratory attendant, John George McKay. The river at the time, the beginning of May, was very low from a spell of dry weather, and on the 9th of May he brought me a smolt and told me that numbers had been picked up at the sides of the Tyne just above Redheugh Bridge. I paid a visit to the region on the 11th, and got ample confirmation of this from the boys who had found them. I obtained fourteen specimens altogether, measuring 12 to 18·7 cm., mostly salmon smolts which had spent two winters in the river and were on their way to the sea. Many smolts must have successfully managed to get past Newcastle in April, and it was only the late migrants of the season which were destroyed. It is

only fair and right therefore to recognise that the destruction has only been a partial one. All the same, the experience of the season warns us as to the extent the effluents poured into the Tyne are becoming perilous.

In addition to smolts, kelts, both salmon and trout, were destroyed at Newcastle, but the effect of the accumulation of poisonous effluents early in May was interesting in another way, for anadromous migrants were poisoned as well. One marine lamprey was reported, and many elvers, the pioneers of the season, were picked up. Young marine fish were included amongst the losses, the presence of which so far up the river is noteworthy. Two flounders were brought to me measuring 8·8 and 11·7 cm.; but of especial interest were young herring in their first year. Three were brought to the Laboratory on the 19th and 20th of May, measuring 5·6, 5·9 and 7 cm., and at the whitebait stage. On the 24th May specimens of still younger herring, measuring 4 to 4·5 cm. in the post-larval phase, were brought from the Gateshead side of the river, with the report that they were lying in large numbers on the shore. It is evident that the herring had drifted up with the tide, and had they not been poisoned would have been carried down again with the ebb. The occurrence serves to indicate the long period during which the herring are passive denatant migrants before they become strong enough to become contranatant. Reasons are given on page 11 for believing that these post-larval herring have been derived from the spawning at the beginning of this year in the Firth of Forth.

The experience of the season of 1917 will have to be kept in mind, for apart from sentimental considerations relating to the repute of the river as a salmon river, the cleaning of the Tyne and the tributaries of the Newcastle region ought to be included in a rigorous scheme of town-planning, which it is hoped one day soon will be adopted and carried into effect. The manufacturers and others concerned will have to treat the effluents so as to render them innocuous, and in doing so will probably discover that the by-products have been more than worth the expense. The cities will also have to consider how far it is desirable to treat the sewage so that the river and the tributaries may not continue to be, what they have already become, open sewers.

REPRODUCTION IN *GRANTIA COMPRESSA*.

By OLGA M. JORGENSEN.

The following observations on the common calcareous sponge of our coast, *Grantia compressa*, were made from serial sections of material collected at Cullercoats at short intervals between July, 1915, and July, 1916, fixed in formalcohol, decalcified and stained in iron hæmotoxylin. The specimens fixed varied from $\frac{1}{4}$ to $\frac{3}{4}$ inch in length, and were sectioned both longitudinally and transversely.

Breeding Season.—My intention was to determine the time at which the germ cells appeared and were developed in this sponge by taking successive batches of material, but the first specimens obtained, from July 22nd to 27th, showed large quantities of fully developed ova, together with numerous well grown embryos, so that the earliest stages were lost.

A little later, August 17th, the sections showed a great decrease in the number of ova though older stages of embryos were still plentiful. On September 4th, no embryos remained within the maternal tissues.

Further collections were made every few weeks, but no reproductive bodies were observed until June, 1916, when very small germ cells made their appearance. Thus it would appear that on the Northumberland coast the breeding season of *G. compressa* lasts from June to the beginning of September. This is strikingly different from what takes place in the species at Plymouth, as shown by Mr. Orton's work there (1). He states that *G. compressa* is an annual sponge, growing and breeding in spring and summer and disintegrating in autumn. Breeding begins in April, the embryos being freed in June. The fact that embryonic stages are still plentiful in August indicates the occurrence of two breeding seasons—the larger (*i.e.*, the older) specimens reproduce early, giving rise to larvae which grow rapidly and are themselves able

to reproduce before the end of the summer. It would appear that there is nothing comparable to this as far north as Cullercoats, where breeding begins so much later.

Ova.—The fully developed ova present in July are remarkable for their immense size. They are more or less oval in outline, except for an attaching pseudopodium to which I shall refer later. The cytoplasm is granular and fairly deeply staining. The nucleus is large, vesicular, very faintly staining, with distinct, eccentrically placed nucleolus stained almost black (Fig. 2). These ova lie behind the flagellate chambers attached to the gastral epithelium.

Maturation and Segmentation.—In only one case have I been able to find what I take to be the first maturation spindle (Fig. 1), though the stage immediately following the extrusion of the first polar body is rather more common. This stage is shown in Figures 2 and 3, the second of these showing the nucleus already in the spireme stage of the second maturation division, while Figure 4 represents the end of the division, the second polar body having been cut off but not yet completely extruded from the cytoplasm. Figure 5 shows the second polar body.

After fertilisation, total and equal segmentation takes place up to about the seventh or eighth division (Figs. 6 and 7), after which a small number of cells at one pole increase in size, become more granular and divide much less quickly than the smaller cells, which now begin to elongate radially. The embryo becomes convex at the pole occupied by the smaller columnar cells, and flattened in the region of the granular elements (Fig. 8).

The Pseudogastrula.—As development continues the number of granular cells increases more quickly, but instead of growing outwards they become temporarily invaginated into the segmentation cavity (Figs. 9 and 10), giving rise to the pseudogastrula, the significance of which has given rise to so much speculation.

Writers on the subject vary greatly in their views as to the importance of this stage. Balfour attaches no importance to it, whilst Sollas explains it as being an attempted reversion to an ancestral type, and as suggesting affinities with the Coelenterates. Dendy (2), however, puts down its formation in *G. labyrinthica*

to purely physical causes due to the position of the embryo which, he states, invariably lies with the granular pole in close proximity to the body of the sponge, so that a wall of spicules presses against it, and so prevents the now rapidly proliferating granular cells from occupying more space outwardly—hence the formation of the pseudogastrula, at which stage he supposes the embryo to be set free. This, however, hardly meets the case in *G. compressa*, at least, for in this species a later stage is present in the tissues of the parent sponge, showing a further increase in the number of granular cells and their subsequent evagination to form a more or less globular embryo. This being the case, the spicules are evidently not able to retard the outward growth of the granular cells. The embryo lies immediately behind the gastral epithelium, which becomes bulged out by the growth and finally ruptured to set it free. Thus when the space between the wall of spicules and the flagellate chamber becomes too narrow to contain the embryo, the proliferating granular cells pressing on the spicules will simply push the opposite pole more closely against the gastral epithelium, so causing it to bulge out more and more until the limit of its elasticity is reached, and it splits, setting free the embryo into the flagellate chamber. The fact that the pseudogastrula stage occurs I take to be due rather to reduction in the pressure of the contents of the segmentation cavity, as it is a strikingly noticeable fact in sections containing large numbers of ova and embryos that, while unsegmented ova and embryos at, or just past, the pseudogastrula stage may be very plentiful, the intervening stages are comparatively rare. This points to a period of very rapid growth fron the beginning of segmentation up to the formation of the pseudogastrula—indeed so rapid that the expansion of the segmentation cavity proceeds more quickly than the rate of absorption of fluid from outside, hence a drawing in of the less convex pole, *i.e.*, the granular cells and the production of the pseudogastrula.

As these invaginated cells increase numerically they become differentiated into two types—a single outer layer of lightly staining cells with definite nuclei and distinct outline, and an inner mass of closely packed elements filled with granular matter and of ill-defined outline. These cells are evidently concerned with the storing up of food reserves for the free swimming period, and as

this continues the segmentation cavity becomes so much decreased that further growth must take place outwards, causing the subsequent evagination which leads to the stretching and rupture of the gastral epithelium (Fig. 11). Previous to the setting free of the embryo, the columnar cells have developed cilia, but having examined only preserved material, I have, of course, not observed these.

Up to the time of writing I have had no opportunity of following the post-embryonic life of this sponge. A couple of specimens, measuring 1·5 mm. were sectioned transversely and showed a ring of oval flagellate chambers surrounding a central cavity, and having distinct inhalent and exhalent canals showing that even such minute specimens as these have attained to the adult form.

Orientation.—The question of the orientation of the sponge embryo is one which seems to have received little attention, though the apparent lack of attention may indicate rather a lack of definite results on this point. There is little difficulty in determining the polar bodies in connection with the ova, but to detect them with certainty in later stages when they have more or less degenerated and lie amongst numbers of small choanocytes is by no means an easy matter. From the few doubtful cases I have seen, however, it would appear that these bodies lie at the pole occupied by the columnar (*i.e.*, future ciliated) cells. (*See* Fig. 13.) This view is supported by a small piece of negative evidence. The proximity of the choanocytes makes the polar bodies difficult to identify, and in the majority of cases at least—according to Dendy, in every case—it is the columnar cells which lie next to these so that the granular pole of the embryo is less frequently hampered in this respect. The position of the embryo, then, is such that, did the polar bodies lie at the granular pole, they would be comparatively easy to identify. Their apparent absence then from this pole, together with a few doubtful cases of their presence at the opposite pole would seem to suggest that the columnar, ciliated cells are developed at the animal pole, which is the anterior end of the free-swimming larva and the pole at which fixation takes place.

Origin of Ova.—The elements which give rise to the germ cells in calcareous sponges have formed a subject for much con-

flicting opinion, these being, according to various authors, amoebocytes (3), archeocytes (4), choanocytes (5 and 6).

In the material of June, 1916, the earliest stages in the development of the germ cells were found. These varied considerably in size, and were situated behind the choanocytes of the flagellate chambers—the smallest being actually amongst them—that is to say, on the same side of the gastral epithelium. This at first sight suggests their having originated here, but on referring to Professor Dendy's work (3) I found that in *G. labyrinthica* "the ova are *obviously* derived from amoeboid wandering cells." Although the young germ cells themselves appeared in many cases to be amoeboid it was not at all obvious from my preparations that they originated from amoebocytes, wandering in the mesoglea, for the smallest cells recognised as future ova were not only invariably situated among the choanocytes but were at first no larger than these, and differed from them only in being less elongated, being without the characteristic collar and in taking the stain more deeply (Figs. 12 and 14). In not a few cases these very young oogonia appeared to retain traces of a collar (Fig. 12), but owing to their smallness and the crowding of the cells together, it is difficult to be absolutely certain. The observations of Carter and Saville-Kent also bear out this view that the oögonia are derived from the collar-cells.

In his last work on *Grantia*, Dendy (1) also comes to the conclusion that though the ova originated as amoebocytes, these amoeboid cells are themselves derived from the collar-cells.

Affinities.—This being the case we are led back to the old theory of the close relationship of the *Porifera* (or at least *Calcarea* like *Grantia*) to the Choanoflagellates. The fact that the choanocytes are responsible for practically all the essential functions of the sponge, including reproduction, indicates that the latter is little more than a colony of choanoflagellate Protozoa. Such a colony would originally be reproduced by the setting free of a collared cell which by fixation on a new site, followed by repeated division, would give rise to a new colony. If we imagine that, in the course of evolution, such a cell becomes provided with larger quantities of nutritive material for the free-swimming period, causing an increase in size until the limit of growth is reached and division takes place before the cell is set free, we have exactly

what happens in *Grantia*. The later differentiation of the embryo into columnar and granular cells is accounted for by the absorption by the latter of increased quantities of food necessary for the free life of the larva. Also if we look upon the formation of the pseudogastrula as due to physical causes only, its presence offers no obstacles to this view.

If it is correct that the sponge larva settles down by, and becomes invaginated at, the animal pole, this removes the supposed homology between it and the embryo of the Coelenterates, the only other group to which it is possible to trace a relationship, and suggests rather that the two groups have originated quite independently.

This would make it fairly certain that *Grantia* and the other similar forms reproduced from choanocytes are not far removed from the colonial Choanoflagellates, and are much more closely allied to these than to any other known forms in the animal kingdom.

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KEY TO PLATE.

FIG. 1.—Mature oocyte lying behind gastral epithelium; nucleus at beginning of first maturation division.

FIG. 2.—Ovum after extrusion of first polar body showing pale nucleus and deeply stained nucleolus; attaching pseudopedium present.

FIG. 3.—Ovum with nucleus at beginning of second maturation division.

FIG. 4.—Ovum showing first polar body formed and second one cut off from nucleus.

FIG. 5.—Ovum after extrusion of second polar body. Two nucleoli are present as is not infrequently the case in ovum of *G. compressa*.

FIG. 6.—Embryo at beginning of segmentation; the two-cell stage.

FIG. 7.—Section of blastula.

FIG. 8.—Longitudinal section of embryo after differentiation into columnar cells and smaller number of granular cells at posterior pole.

FIG. 9.—Section of slightly older embryo; granular cells beginning to be invaginated into segmentation cavity.

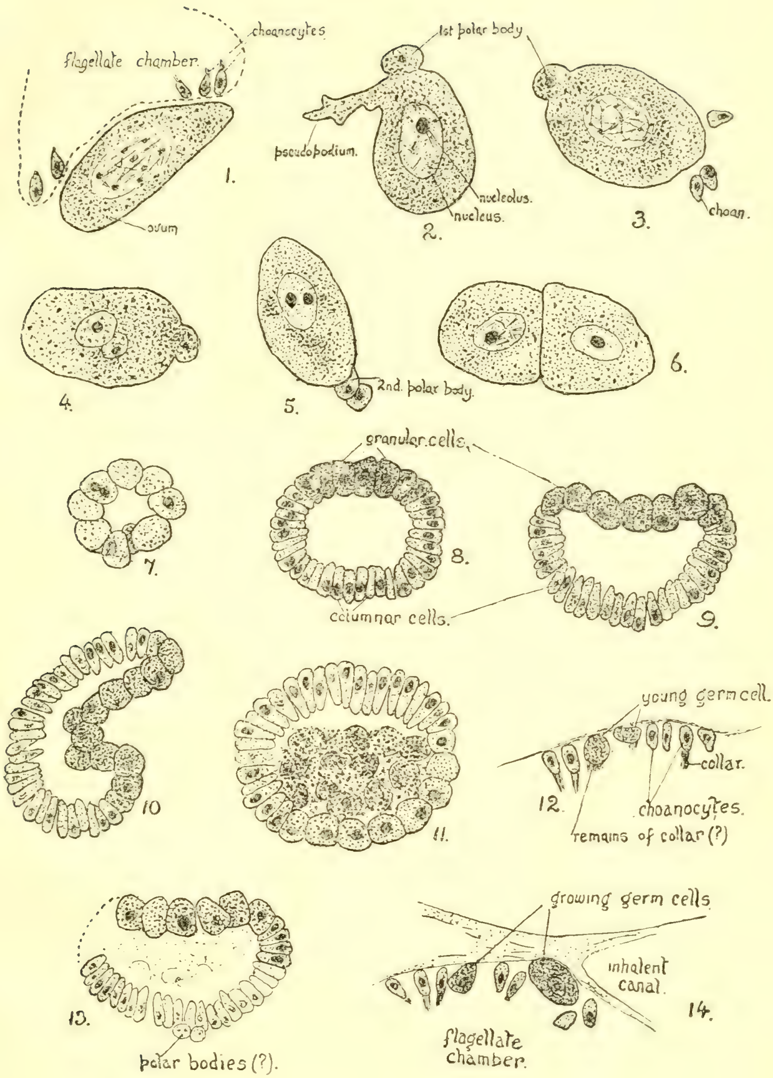
FIG. 10.—The pseudogastrula in longitudinal section; granular cells increasing in number.

FIG. 11.—Section of older embryo just before being set free; granular cells evaginated and differentiated into single outer layer and inner mass of nutritive cells.

FIG. 12.—Portion of wall of flagellate chamber showing choanocytes, two of which have become rounded off as future germ cells; remains of collar still present.

FIG. 13.—Section of embryo with remains of polar bodies (doubtful) at anterior pole.

FIG. 14.—Part of flagellate chamber and inhalent canal showing position of germ cells slightly older than those in Fig. 12; larger one with characteristic nucleus and nucleolus.



REPRODUCTION IN *GRANTIA COMPRESSA.*

ON THE PHORONIDEA.

By A. Meek.

CONTENTS.

1.—*PHORONIS OVALIS* AND *ACTINOTROCHA BRANCHIATA*.

An interesting and important paper has been published this year by Harmer * in which the rediscovery of Strethill Wright's *Phoronis ovalis* is recorded. In 1856 Strethill Wright published his account of *Phoronis hippocrepia* got at Ilfracombe, and of *Phoronis ovalis* obtained from an oyster shell dredged near Inchkeith, in the Firth of Forth. Harmer found on examining an empty shell of *Neptunea antiqua* sent to him from the Cullercoats Laboratory that *Phoronis ovalis* and other animals and algae occupied burrows in the shell.

The record is of interest to the Laboratory, for the shell was procured from 16 fathoms to the north-east of Cullercoats, and it is particularly interesting to me, for before the paper was published, I had taken out and dusted a research I made in 1890-91 at St. Andrews in the old Marine Laboratory (where before the present Gatty Laboratory was erected so many workers obtained their training in marine zoology; workers now scattered all over the world, who retain many pleasant recollections of the old laboratory, and recall with feelings of pride and thankfulness the help they received from their distinguished leader, Professor McIntosh). The investigation done at St. Andrews referred to the

* "On *Phoronis ovalis*," Strethill Wright. Quart. Jour. Micros. Sc., vol. 62, 1917.

structure of the larva, the changes undergone during metamorphosis, and the structure of the newly metamorphosed Phoronis, and with a view to completing it after all these years I had already procured and examined carefully many shells got from trawlers and from our dredging trips, and I can assure Dr. Harmer that the creature is not so common as his discovery might lead him and others to suppose.

Actinotrocha branchiata.—The larva was discovered before the adult; it was one of the many forms found by J. Müller* by the use of a plankton net at Heligoland. He called the larva *Actinotrocha branchiata*, but he thought it was an adult and belonged to the Turbellaria. Since its discovery by Müller it has been found at several places on the British coasts of the North Sea. There is little doubt that the Actinotrocha found by Cobbold near Portobello, in the Firth of Forth, was this species, for it has often been obtained in the Forth since. Cunningham † found it in September, 1883, a little to the north of Cromarty Firth. I ‡ netted many specimens in Sullom Voe, Shetland, in the beginning of August, 1891.

In the St. Andrews region it has been procured from Easthaven, near Carnoustie, north of the Firth of Tay, to the Firth of Forth. It was first observed in 1888, was scarce in 1889, but during the summer of 1890 it occurred in great profusion in St. Andrews Bay; in 1891 and 1892 it was again far from plentiful and late in appearance. In 1890 the young stages were found at the surface in July in great quantity. During August the supply gradually declined, but a few were still forthcoming in September and even October. The young Phoronis was found in small numbers in July, and was quite common in August and September. The older larvae sink, and are found with the young Phoronis at the bottom.

Off the Northumberland coast the larva has been found in small numbers in July, August and September from the neighbourhood of the Farnes to Newbiggin,§ and in large numbers on July 24th, 1899, about a fathom from the surface, about five to six miles north-east of Cullercoats, in 23-26 fathoms.||

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* 1846. Müller's Archiv.

† 1886. Nature, v. 34, p. 361 ‡ 1891. Nature, v. 44, p. 344.

§ Rep. Dove Marine Laboratory, New Ser., 11, pp. 66-68, 1913.

|| Rep. Dove Marine Laboratory, 1899, p. 58.

The larvae may therefore be said to be prevalent during a period of about three months, but mostly in July and August. At St. Andrews it may be said to occur inshore, certainly well within the bay; on the Northumberland coast it is never found in any of the bays, but well out from the coast, except at the north end of the county, in the neighbourhood of the Farne Islands, where it has been found nearer the coast.

This all goes to show that in the North Sea the larvae are liable to a period of denatation, a drift taking place which serves to unite the whole of the east coast of Scotland and Northumberland with the eastern coast of the North Sea. It may be taken for granted that wherever metamorphosis has been seen to take place commonly there also adults are developed. This has been noted at Shetland, St. Andrews and Heligoland. There are probably other centres of dispersal which lie along the path of the ocean current, and the larvae are thus exposed to a dispersal which must take place to the south along the east coast of Britain, ultimately reaching Heligoland, and the south-west coast of Norway. The larva has been found at Bergen, and rarely at Kiel. The variability in the number of larvae in successive years is evidently associated with this denatation.

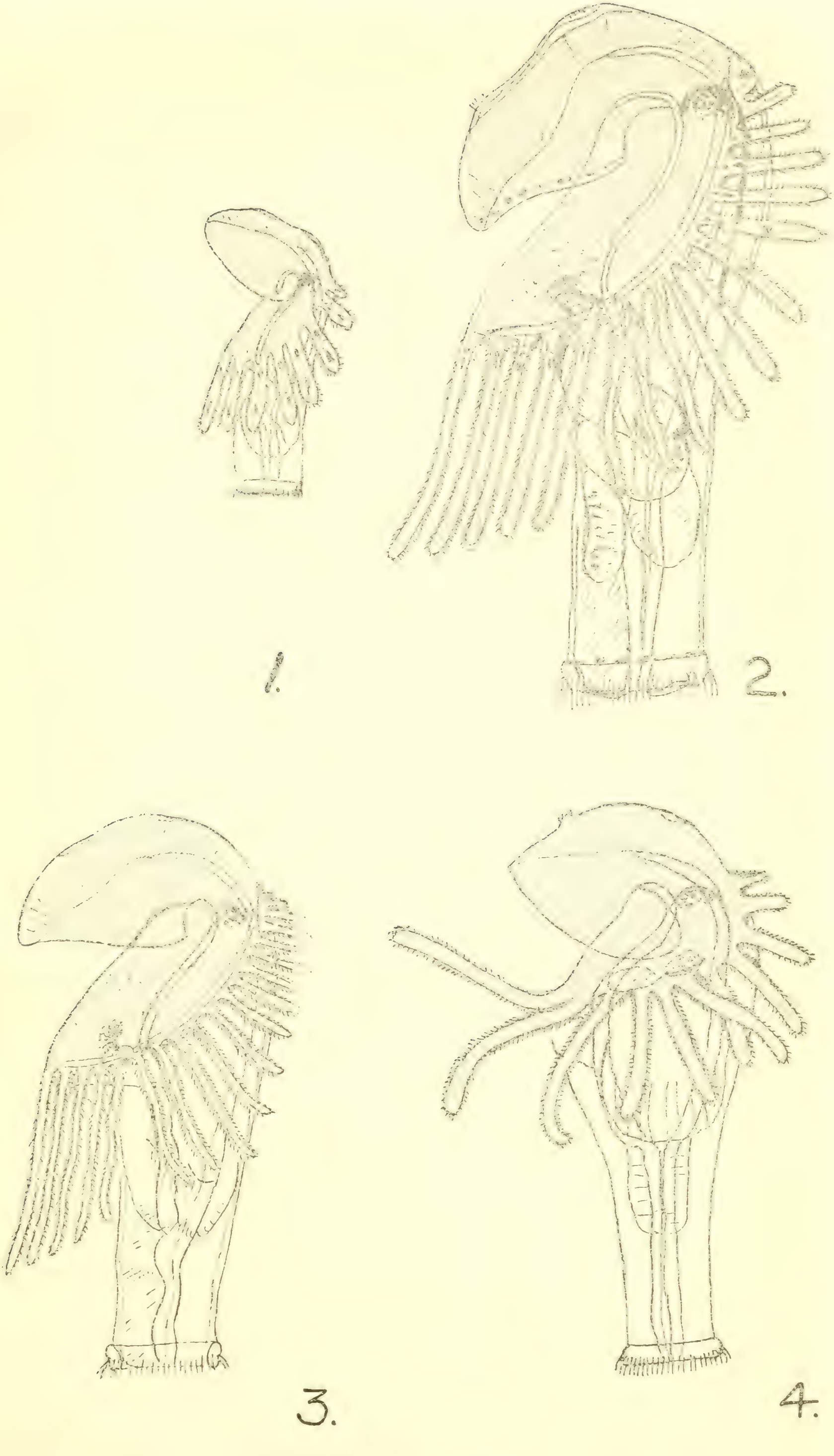
The Shetland, St. Andrews and Northumberland specimens all agree with the form originally described by Müller and by Wagener. Much variation is met with affecting the size, the pigment, the size and number of the tentacles, the shape and size of the anal ring and so on, but when large numbers of specimens are examined it is found that seldom do all the variations occur together, some feature indicates definitely the specific type.

No other species of the larva, except *Actinotrocha branchiata*, has been found on the east coast of Britain, and no other species of the adult than *Phoronis ovalis*, and we are justified for this reason in associating them as the larva and the adult of the same species. Harmer in his paper is disposed to think as he found *Phoronis ovalis* multiplying freely by transverse fission "that all the observed individuals may well have been produced in this way." He forgets, however, that the specimens be examined presented fully developed gonads. We would thus have the paradox that in the same area there is an Actinotrocha the adult of which has never been seen, and a Phoronis which does not yield a larva or yields a larva which has not yet been found.

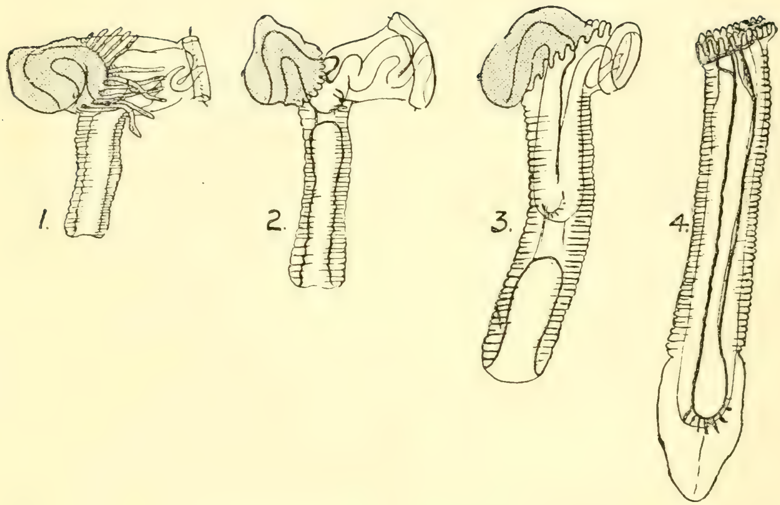
I had already come to the conclusion that the larva I had studied and the adult described by Strethill Wright were the same species from a comparison of the latter with the newly metamorphosed young. Harmer gives the specific characters of *Phoronis ovalis* as follows :—Size, reaching at least 6 mm., the transverse diameter about 0·25 to 0·35 mm.; lophophore oval, much broader than long, and indented as usual posteriorly ; number of tentacles about 22 ; metasome sharply divided into an upper region with strong longitudinal bundles of muscles and a lower region with an extremely thin body-wall in which muscles are absent or at most very slightly developed : about fourteen bundles of longitudinal muscles occur on each side of the upper part of the body. The newly metamorphosed young proceeding from *Actinotrocha branchiata* has the characters :—Size, about 3 mm., the transverse diameter about 0·2 mm.; lophophore oval and indented as in *P. ovalis* ; number of tentacles about 22-26 ; metasome divided into two regions, the upper presenting well-developed longitudinal muscles and the lower being thin-walled, but in this case the lower division is roughly about a third of the upper ; about fourteen bundles of longitudinal muscles on each side in the upper part of the metasome. There can be little doubt therefore that the agreement between the young Phoronis and the adult as defined by Harmer is sufficient to prove that they are the same species. Incidentally, the small degree of development of the lower part of the metasome in the young as compared with the adult serves to show that growth takes place by an extension of the lower end of the metasome, and is thus directly continuous with that which gives rise to the invaginated metasomal wall of the larva.

The larva (Fig. 1) is one of the most graceful which comes under the eye of the plankton investigator. It is transparent, but pigment usually adds to its elegance. Spots of pigment are dotted round the edge of the hood, and on the anal ring, usually two spots are present on each of the tentacles towards their bases and isolated flecks may frequently be seen on the posterior part of the body, and even on the wall of the intestine. The pigment is bright green viewed by reflected light, dark green in transmitted light, and is soluble in alcohol. The larva is liberated when it has about two pairs of tentacles, and the tentacles are added to

1. Actinotrocha from Messina, Mediterranean, type of larva of *Phoronis hippocrepia*, 2. *Actinotrocha branchiata* from St. Andrews, larva of *Phoronis ovalis*. 3. Actinotrocha from Ceylon, type of larva of *Phoronis buskii*. 4. Actinotrocha, after Wilson, larva of *Phoronis architecta*.



PHORONIDEA.—FIGURE I.



PHORONIDEA.—FIGURE II.

Metamorphosis of *Phoronis ovalis* 1, 2 and 4 St. Andrews. July, 1891. 3. Sullom Voe, Shetland, 6th August, 1891.

dorsally in pairs until a maximum of about seventeen pairs may be formed. But metamorphosis may take place when the tentacles number twelve pairs. The variation in this respect may be said to be due to a variation in the length of the planktonic period. The tentacular ring is thus incomplete dorsally as it is in the adult. It is evidently homologous with the postoral ciliated band of many invertebrate larvae. During development a median conical ciliated papilla appears in front of the apical plate, and this may be held to represent the pre-oral ciliated band. The anal band of cilia is borne on immensely thickened ectodermal cells, and has the same disposition as that of the Tornaria larva. The larva measures when fully grown about 1·5 to 2·5 mm.

As is well known, the metamorphosis and the preparation for it are characteristic and unique. Adult tentacles appear as rudiments posteriorly to the larval tentacles, and on the mid ventral surface just behind the adult tentacles a small patch of the ectoderm is folded inwards, traversing the ventral mesentery of the body cavity, and forms a winding tube within the body. When this is completed the larva has reached the bottom as a rule. Metamorphosis takes place through the evagination of this tube. It is rolled out as will be seen from Fig. 2 in such a way that the blind end of the tube is the last part to appear. It is not until the blind end of the tube has left the larval body that the alimentary canal of the larva is pulled into it, the larva at the same time suffering contraction. At this period of the changes the hood is withdrawn or may be swallowed literally together with the larval tentacles, and as a last effort the anal ring is pulled in, the cells either before or after sinking to a size more like those on either side. All this brings the tentacles and the oral field into the horseshoe shape so characteristic of the adult. Much variation accompanies the metamorphosis, especially as to the fate of the tentacles. They may be cast off before the tube begins to appear, or they may be retained until the process is completed. When the tentacles are cast off they are swallowed, for their remains are to be seen in sections of the stomach, as de Selys Longchamps has already pointed out. The whole process only lasts about a quarter of an hour.

I have had, thanks to Professor Herdman, an opportunity of examining the specimen of Actinotrocha which he captured at

Bute in August, 1888. It measures as mounted about 0·8 mm., and possessed 13-14 pairs of tentacles. Mr. James Dick, M.A., Glasgow, through the kind offices of Dr. Gemmill, was also good enough to send me a number of carefully made mounts of Actinotrocha from the Clyde. One was as small as 0·57 mm., and had only six pairs of tentacles, and the appearance of de Selys Longchamps Fig. 11, Plate II., of *A. hatsckeki* ; some had twelve pairs of tentacles, and two had evidently about seventeen pairs of tentacles. It is difficult to identify species in the case of preserved specimens, but I came to the conclusion that the Clyde larvae also belonged to this species, even the small one mentioned, for similar specimens have been got at St. Andrews. Besides the localities already given, tha larva is common in the Mediterranean, at all events, at Naples and in the Adriatic. De Selys Longchamps says it is found at Plymouth, but according to Allen (in a letter) the Actinotrocha they get is the larva of *P. hippocrepia.*

It is evident then that *Phoronis ovalis* is more widely spread than the records indicate, and it is probable therefore that it is liable to considerable modification as we have seen the larva is. The tentacles of the larva during its period of growth are added to in pairs, and metamorphosis may take place before the maximum number is reached. As will be apparent presently the adult also adds to its number of tentacles in the same manner. The tentacular crown moreover is liable to be thrown off and renewed. We cannot therefore insist too strongly on the number of tentacles as a specific feature. The shape of the lophophore is probably more constant, but in the same species it is liable to be more folded inwards in some of the examples than in others. The size, as Harmer has indicated, is very variable. The characters are thus very vague, and in detailing them liberal use of numbers and descriptions must be admitted. Probably the character which might with most reason be appealed to is the number of longitudinal bands of muscles in the upper half of the metasome, but even this is variable. *Phoronis ovalis* has only been found hitherto in shells, but so rarely that it need not surprise us to find that it may have to be content to form its tube in sand or in stones, and, if so, it may be found to vary according to the conditions. We have to remember too the long denatation to which

the larva is liable. The youngest larva I saw at St. Andrews had six pairs of tentacles, and had therefore been free for some time. The majority found in St. Andrews Bay are already advanced in growth, and young Phoronis are found almost as soon as the larvae. It is not the same stock that is found throughout the three or four months of the summer and autumn, but a stock which is being constantly supplied by the currents, in this case from the north. The species like other meroplanktonic forms may be pictured as being rotated generation after generation along with the prevailing current of the region. It may be pelagic for many weeks, and thus have the time to be carried a long distance before it reaches the bottom, and there is no contranatation. With this in mind an attempt may now be made to briefly consider the described species of Phoronis and of Actinotrocha.

2.—SPECIES OF PHORONIS.

Phoronis ovalis, Strethill Wright.—The characters and the distribution have already been given. The Phoronis described in 1858 by van Beneden * under the name *Crepina gracilis* may be included here. It was obtained in an oyster shell, but van Beneden did not state where the shell was procured. The lophophore was similar to that of *P. ovalis*. The animal had a length of 8-10 mm., and a diameter of about 1 mm. The tentacles were found to be very variable in number. "Nous en avons compté quelquefois vingt-quatre, d'autres fois le nombre s'élevait à trente et même quarante." Van Beneden observed also the renewal of the tentacular crown. De Selys Longchamps † has described *P. mulleri* from Heligoland, and believes that it is derived from *A. branchiata*. If this be the fact and the above contentions sustained, then the size is still further increased—to 40 to 80 mm., and the number of the tentacles to 50 to 60; the longitudinal muscles number 24. De Selys Longchamps states that the left lateral mesentery is not developed. This is evidently also the case in *P. ovalis* as it is in the metamorphosed *Actinotrocha branchiata*.

Phoronis euxinicola, de Selys Longchamps, got at Sebastopol, is nearly allied. The lophophore has, however, the shape "5,"

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* Ann. d. Sc. Nat. (Zool.), T. 10, p. 11.

† Wiss. Meeresunters Kiel u. Helgoland, Bd. VI., 1903.

and this, it will be observed, would be easily derived from the type " 6," and is practically realised in some of the young examples of *P. ovalis* (Fig. 3).

Phoronis architecta, Andrews,* was found at Beaufort, North Carolina. It has a lophophore of the type " 4 " (Fig. 3) and thus approaches closely to the Mediterranean and eastern North Atlantic types referred to below. The animal lives in muddy sand, and the tubes are encrusted with sand grains. The longitudinal muscles number about 43, and are especially strongly developed in the upper part of the metasome. The tentacles are about 60 in number. The young Phoronis obtained by Willey † from the metamorphosis of an Actinotrocha captured in St. Andrews Bay, New Brunswick, and the young Phoronis obtained in the same way by Wilson ‡ from Chesapeake Bay may belong to this species.

Phoronis sabatieri, Roule (40 to 50 tentacles, 25 to 30 longitudinal muscles, Mediterranean).

P. psammophila, Cori (tentacles 60 to 106, 32 to 39 longitudinal muscles, Mediterranean).

These have been united by de Selys Longchamps, and so far as the shape of the lophophore is concerned they agree also with *P. kowalevskyi*, Benham (tentacles 60 to 126), and *P. hippocrepia*, Wright (tentacles 16 to 130, longitudinal muscles 30 to 40).

P. sabatieri is evidently usually fixed to shells by its tube, *P. psammophila* is found in sand, *P. kowalevskyi* occurs in colonies adhering to piles. *P. hippocrepia* has been obtained from burrows in stones, and since its discovery on the shores of the Bristol Channel has been captured at several places in the English Channel and is recorded from the Clyde.

Phoronis ijimai, Oka, Japan, according to Ikeda is indistinguishable from *P. hippocrepia*. It forms encrusting colonies like *P. kowalevskyi*. The tentacles number 150 to 210, and the length of the animal is 40 to 100 mm.

P. pacifica, Torrey, California, is evidently closely related to *P. ijimai*.

Phoronis buskii, McIntosh, Philippines, lophophore still further enrolled leading to the condition of *P. australis*, Haswell. *P.*

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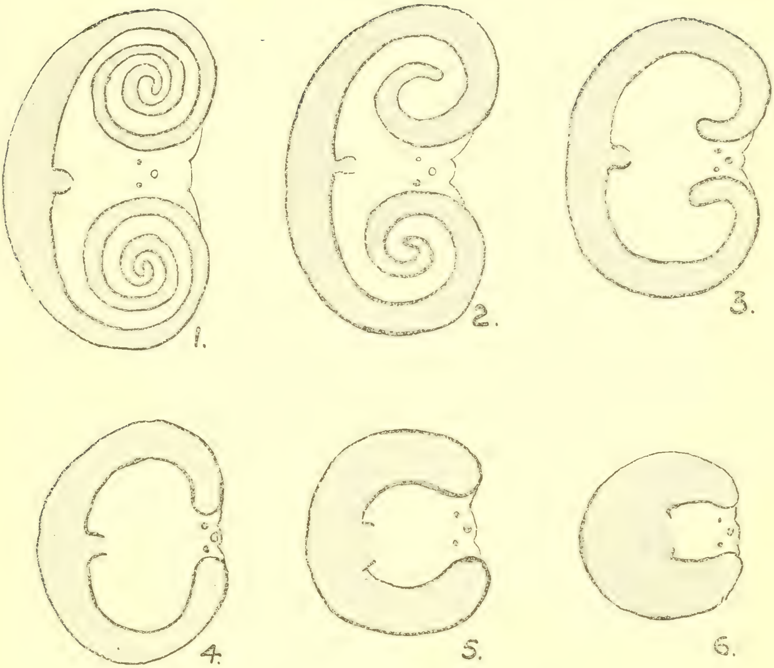
* 1890. Ann. and Mag. Nat. Hist., v. 5, 6th ser., p. 445.

† 1915. Contributions to Canadian Biol., No. 396, p. 6.

‡ 1881. Quart. Jour. Micros. Sc., v. 21, p. 202.



PHORONIDEA.—FIGURE III.

Lophophores of 1, *Phoronis australis* (after Benham); 2. *P. buskii* (after McIntosh); 3, *P. architecta* (after Andrews); 5. *P. euxinicola* (after de Selys Longchamps); 6, *P. ovalis*.

buskii has a length of about 520 mm., possesses numerous tentacles and some 84 longitudinal muscles. *P. australis* reaches a size of 127 mm., and also has numerous tentacles and the longitudinal muscles number about 47.

3.—SPECIES OF ACTINOTROCHA.

De Selys Longchamps showed a disposition to analyse the species of Phoronis with suggestions as to forms which should be united, but in the case of the larvae he contented himself by giving all the varieties which had been described and added a number of his own to the list. Many of the so-called species have been described from mounted and preserved specimens, and the characters in many cases at least appear to be due to contraction and distortion. The number of tentacles is not sufficient to indicate the species even at the time of metamorphosis. The size is a guide, and indeed the size and the relative number of tentacles are with the general shape all we have to depend upon for distinguishing the species.

Actinotrocha branchiata, Müller.—The characters and distribution of this species have already been considered. It is found, as has been noted, from the Mediterranean to Norway. *A. gegenbauri* (Messina), which measures 2·5 mm. and has twelve pairs of tentacles may be included here, and also *A. ornata* (Nice) which only differs with respect to pigment, and this is very variable. *A. dubia*, found at Naples, measured in the contracted condition 1 mm., and possessed ten pairs of tentacles ; *A. olgae* also obtained at Naples, agrees with *A. branchiata* in size, and has ten pairs of tentacles. Possibly *A. brownei* which has been caught off the west coast of Ireland and in the Channel at Plymouth, and which presents twenty pairs of tentacles might be brought into this group, as an overgrown oceanic larva.

A. pallida, Schneider, only measures 0·6 mm., and has six pairs of tentacles. It was got at Wimereaux and at Heligoland. *A. metschnikoffi* from the Mediterranean also has a size of 0·6 mm., and possesses eight pairs of tentacles. *A. sabatieri* reaches a size of 0·8 mm., and the tentacles number twelve pairs. The species described as *A. hatscheki* and *A. ashworthi* have the same general characters. This species or group of species may be said to be

related to *P. hippocrepia* as the *A. branchiata* group is related to *P. ovalis.* This small Actinotrocha is illustrated in Fig. 1 from a specimen which Professor Goodrich kindly lent me. This specimen he obtained from Faro, Messina.

The two types of Actinotrocha described by Wilson from Chesapeake Bay appear to be related the one to the *A. branchiata* and the other to the *A. pallida* group. His A form is reproduced in Fig. 1, and this probably developes into *P. architecta.*

A. henseni from the coast of Brazil, measuring only 0·3 mm., with six pairs of tentacles, is a young stage.

Many species of Actinotrocha have been described from the Indian Ocean and Western Pacific. It is interesting to note that *A. ikedae,* of Japan, which measures 1 to 1·5 mm and possesses eight pairs of tentacles, is believed to be the larva of *P. ijimai.* The other species are larger, and have a large number of tentacles, from 18 to 24 pairs, and appear therefore to be related to *P. australis* and *P. buskii.* A figure of this type of larva is given from a specimen from Ceylon, for the loan of which I have to thank Professor Goodrich.

A. spauldingi, California, measuring 1·75 mm., eleven pairs tentacles, is believed with reason to be the larva of *P. pacifica,* and it is evidently related to the Japanese *A. ikedae.*

As a result of this rough and somewhat cursory analysis I venture to suggest that we have in the North Atlantic and Mediterranean what may be called two specific types :—

Phoronis ovalis with *Actinotrocha branchiata.*
P. hippocrepia with *A. pallida.*

In the Indo-Pacific region, in addition to species allied to if not identical with *P. hippocrepia*, there are large species of the type *P. buskii* which are peculiar to the East Indian region, and these too are related to *P. hippocrepia.* The northern Atlantic forms may thus be imagined to have gained the north as far back as the late Mesozoic when the Indian Ocean was formed and the way opened to spread into European waters.

The planktonic period may be longer than has been believed, and it is not unlikely that it may be prolonged under certain conditions. Willey, for example, was perhaps not so far wrong when he identified the specimen he got in New Brunswick waters

as *A. brownei.* The fact that the latter was got off the west coast of Ireland points to a drift of an oceanic character.

All this may be said to be vague and not scientific, but does it add to clearness and is it any more scientific to keep on tagging specific names to every seeming variety which comes into the hands of the collector? The Phoronidea is not the only group which suffers from this practice.

Strictly speaking, the group should be called the Actinotrochidea, and the genus Actinotrocha, but as no one can estimate the time it will take to finally resolve the relationships of the larvae to the adults, I venture to suggest that Phoronis be finally adopted as the generic name, with *Phoronis hippocrepia* as the genotype.

4.—DEVELOPMENT AND STRUCTURE.

I do not intend to give a detailed account of the structure, for the work I did so many years ago will have to be relegated to the scrap heap from the papers which have been published since. but I do not think that even Goodrich will find fault with me for saying that I saw and sketched the solenocytes and had called them excretory cells. I shall content myself with giving here a summary of the important facts of development, of the structure of Actinotrocha, and of the changes produced at metamorphosis.

1. Development.—The early development takes place in the tentacular crown as a rule. Total segmentation leads to the formation of a blastula, and a gastrula is derived by invagination. According to de Selys Longchamps the lips of the blastopore fuse posteriorly and the anterior end persists to become the mouth. The whole blastoporal area, however, is involved in the stomodeal invagination. Mesenchyme is developed from the entoderm as isolated cells. Ultimately there arise therefrom (1) a blastocoele which occupies the pre-tentacular zone of the body of the larva—the oral field region indicated by shading in Fig. 1 including the larval tentacles; (2) a narrow body cavity—the lophophoral cavity—which is associated with the adult tentacles; (3) the trunk body cavity which occupies the post-tentacular region of the body. The mesoderm also gives rise to blood vessels and blood cells.

It is thus evident that in the plane of the tentacles there is a mesentery or septum stretching across the body obliquely and separating the blastocoele from the trunk body cavity. The blastocoele is traversed by contractile bands, and is more or less completely lined by cells. The latter are especially well developed in the region of the stomach and oesophagus and the stomodeal wall, and give rise to blood cells by division. The blood cells soon become yellow and then red with haemoglobin. The trunk body cavity consists of a parietal layer surrounding the body, a mesentery connecting the ventral wall of the body with the stomach and intestine, a splanchnopleure surrounding the stomach and intestine, and the septum. The lophophoral body cavity lines the adult tentacles and the part of the adjoining wall of the body between the tentacles and the septum; its visceral layer separates the cavity from the blastocoele. In the tentacle a mesentery is formed on the outer wall, which expands in the centre into a blood vessel opening into the blastocoele. A proliferation of the splanchnopleure of the trunk body cavity just below the septum and extending downwards for a short distance on the dorsal aspect of the stomach gives rise to a blood vessel which is at first a closed structure but later becomes open in the larva and likewise communicates with the blastocoele. A lateral vessel is also developed on the lower left aspect of the stomach, and this vessel is produced into numerous blind diverticula. These vessels are indicated in the figure of *A. branchiata* (Fig. 1).

The nephridia are of ectodermal origin. They occur as ingrowths in the neighbourhood of the anus, and like the latter therefore are post-blastoporal in origin. By the growth of the larva in this post-blastoporal part of the body the anus and the nephridia come to be widely separated, the anus remaining at the posterior end of the body and the nephridia coming to occupy a position just posterior to the tentacles. They project into the blastocoele in front of the septum, and the bifurcated blind end is clad with solenocytes as has been described by Goodrich and others. The influence of the action of these is shown by the position taken up by the blood cells. These are arranged in two heaps near the blind end of each nephridium, and it is evident that the heaps are of physiological origin for they tend to be broken up when the larvae are killed.

The larval tentacles are flattened on the medial side, where the ectoderm is thin. The adult tentacles are circular in section, and the cells are similar in all parts of the section.

The nervous system of the larva is closely associated with the ectoderm, and lies outside the basement membrane of the ectoderm. It consists of the apical plate ganglion or brain and nerves which proceed from it. Three nerves run forwards, a median and two lateral. The median nerve supplies the papilla of the hood where the nerve expands into another ganglion with a few nerve cells. Two nerves leave the brain posteriorly and follow the tentacles fusing on the ventral side of the body. In my notes I appear to have observed two pairs of sense organs on the dorsal wall just below the level of the septum.

It has already been stated that the growth of the larva after gastrulation especially takes place by an outgrowth of the post-blastoporal region. The intestine is put into communication with the terminal part of this outgrowth, and in the region intervening between the anus and the tentacles a thickening appears. This thickening of the ectoderm is ultimately with the completion of growth carried into the interior as the metasome. As has already been said, it passes in between the two layers of the ventral mesentery, and the mesentery accompanies it as it folds to adapt itself to the space between the body wall and the alimentary canal. The coelomic epithelium is thickened around the metasome by developing folds, and the metasome becomes attached in this way also to the stomach.

The general effects of the metamorphosis are quite apparent. The tube is unrolled as has already been stated, the larval tentacles are thrown off, and after the change has occurred, the two openings of the alimentary canal are rotated towards one another. The oral field is resolved into a horseshoe shape, and the anus is received into the space between the two wings of the horseshoe. The internal changes are also not difficult to appreciate. The alimentary canal becomes U-shaped, the trunk cavity of the larva now forms the cavity of the metasome, and the lophophoral cavity takes up its place under the lophopore. The septum serves now therefore to separate a small lophophoral cavity from a large metasomal cavity.

I am not satisfied even with de Selys Longchamps' evidence that the hood is sacrificed in the process of metamorphosis. At

St. Andrews I have examined a large number of specimens during and after metamorphosis, and in most cases aided by sections I came to the conclusion that the hood was converted into the posterior moiety of the oral field of the adult. It is a matter of little moment morphologically, for the whole tentacular region may be thrown off and renewed during adult life.

During the metamorphosis the changes in the disposition of the mesentery and the splanchnopleure lead to the dorsal vessel of the larva already in communication with the blastocoele being connected with the lateral vessel, and the latter is also extended to the blastocoele, bifurcating below the septum. The dorsal vessel becomes the afferent vessel, and the lateral vessel the efferent vessel of the adult.

In the newly metamorphosed Phoronis, the nephridia have lost their solenocytes, but what becomes of them I cannot say. The nephridia lie between the septum and the wall of the lophophoral cavity. At this stage they have not yet penetrated the metasomal cavity.

5.—POSITION OF THE PHORONIDEA.

Phoronis is a genus, the developmental and structural features of which render it worthy of class distinction at least, and in consequence many attempts have been made to indicate to which group it ought to be relegated. So far practically every worm group has been suggested and Polyzoa and Brachopoda, and recently particularly the attempt has been made to prove that Phoronis is allied to Balanoglossus and other so-called Hemichordates. Masterman, attracted by the general resemblance of the larva to that of Balanoglossus, has tried to show that Actinotrocha has notochordal structure in the digestive glands, and has proceeded to find coelomic cavities and other features homologous with those of the Enteropneusta and their allies.

The trouble may be said to have begun when Bateson identified the anterior diverticulum of the alimentary canal of Balanoglossus with the vertebrate notochord. This structure which admittedly has a supporting function is quite obscure as to the layer from which it arises, and it certainly is not developed as the vertebrate notochord is developed. In the Urochordata, in the Cephalo-

chordata, and in the Craniates the notochord arises from the dorsal lip of the blastopore after the gastrula has been formed. Even if it be said to be derived from the mid-dorsal entoderm it is still post-gastrular in origin and position. The so-called notochord of the Enteropneusta arises from the anterior region of the alimentary canal at a late period, after the stomodeum has been formed, and from its position it is impossible to say that it is entodermal in origin, any more than, for example, the very similar subneural gland of the Tunicates can be proved to be ectodermal, at all events, the duct of that structure. Even if some are anxious to believe that the proboscis diverticulum of Balanoglossus is truly entodermal, then it must be derived from the extreme anterior end of the enteron and is therefore gastrular in origin. If it be said to be stomodeal then it has certainly nothing to do with the dorsal lip of the blastopore.

Undoubtedly with regard to the pharyngeal gill-slits the Enteropneusta indicate affinities with Amphioxus, but in every other respect they are closely associated with the Pterobranchia and with the Echinoderma. There is a wide hiatus developmentally and structurally between the true Chordata and Balanoglossus, but in development and structure the Echinoderma, the Pterobranchia and the Enteropneusta have much in common. They present a proctodeal blastopore and a hydrocoele, which latter is retained during life. We would be justified in uniting them under such a name say as Hydrocoela.

For these reasons also it is plain that Phoronis is excluded from this group. The blastopore is stomodeal, and there is no hydrocoele. The anterior cavity of the larva of Phoronis, as has been stated, is occupied by a blastocoele in which blood cells may be met with from the hood to the larval tentacles.

We have learned a great deal in recent years as to the fate of the blastomeres, but no morphologist appears to have thought it worth while paying any attention to the directive influence of the blastopore. Yet it is evident that in the invertebrate groups generally, from Coelenterates onwards, it is stomodeal as it is in Phoronis. When an anus is formed the opening takes place by a fresh communication of the enteron with the ectoderm posteriorly to the blastopore. In the Annelids and the Arthropods the mouth and anus are both derived from the blastopore. In the groups

specified above the anus alone is developed from the blastopore, and the mouth is formed in front of it. This is also characteristic of vertebrate development. Chaetognatha may be said to stand more directly in relation to the "Hydrocoela."

This raises the question of the homologies of structural elements related in the one case to a stomodeal blastopore, and in the other to a proctodeal blastopore.

These are matters which need not be discussed here. I content myself with saying that Phoronis must be placed amongst the groups of Invertebrates which present a stomodeal blastopore, and by drawing attention to the fact that the metasome of Phoronis is directly homologous with the foot of Mollusca (and Caldwell was justified in calling it by that name) and with the part of the body of the Gephyrea intervening between the mouth and the anus, the outgrowth of which gives rise to the greater part of the body of the adult.

Reference has been made to some of the papers, but a full bibliography of the subject will be found in de Selys Longchamps' account of Phoronis in Fauna u. Flora d. Golfes v. Neapel, 1907, monograph 30.

THE LAMPREYS OF THE TYNE.

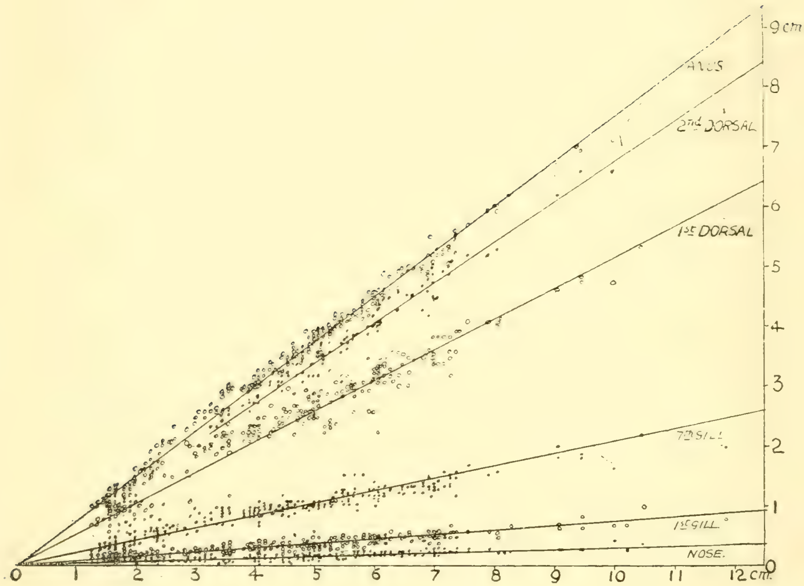
By A. MEEK.

This investigation began at Houxty, Wark, on the North Tyne, on May 20th, 1916. On that occasion our first sample of larval lampreys was obtained in the sandy mud at the side of the river, and as all present were concerned, I here append the names of Abel Chapman, W. F. Henderson and George Bolam and thank all for their help on that and at the next visit mentioned below.

It was continued at Bellingham further up North Tyne in the last fortnight of August, when a large collection was made at various places in the Tyne, in the neighbourhood of Bellingham, and also in the Reed. The collecting at Houxty was continued in September by Mr. Chapman, and at Bellingham and in the Reed in September, October and November by Mr. J. Allen, Bellingham. This year in May another visit to Houxty gave us a further sample at the end of a year. The general details of the captures are indicated in the following table.

From this it will be seen that the larvae are very common, and it is evident also that three or four generations are included in the captures. So far, however, no trace of mature lampreys has been found. Mature lampreys have been seen in the Tyne; I have heard of them in the neighbourhood of Bellingham and opposite Hesleyside. It appears from the table that spawning takes place in June, for the young lampreys obtained in August, measuring about 1·5 cm., are more than probably the product of the year. The larvae grow rapidly after hatching, as has been shown in the case of Planer's lamprey by Goette. They measure on hatching about 2·8 mm., reach 4·5 mm. in four days, and 6·5 mm. in eleven days. The youngest lampreys we got measured 12 mm., and would only therefore have been about one month old at the most. If the incubation period be one of about three weeks the spawning would appear to take place in May and June.

Date.	Place.	Length in Cm.																							
		0·5	1·0	1·5	2·0	2·5	3·0	3·5	4·0	4·5	5·0	5·5	6·0	6·5	7·0	7·5	8·0	8·5	9·0	9·5	10·0	10·5	11·0	11·5	12·0
20th May, 1916	Houxty (Tyne) ...	—	—	—	1	2	—	1	—	1	—	—	2	—	1	—	—	—	—	—	—	—	—	—	—
15th-23rd Aug., ,,	Reed	—	—	7	2	1	—	1	2	2	2	4	2	3	—	—	2	—	1	—	—	—	—	—	—
,, ,,	Bellingham (Tyne)...	—	4	16	4	1	9	10	13	5	14	5	4	1	3	—	—	—	—	—	—	—	—	—	—
	Total... ...	—	4	23	6	2	9	11	15	7	16	9	6	4	3	—	2	—	1	—	—	—	—	—	—
14th Sept., ,,	Bellingham (Tyne) ...	—	—	1	—	—	1	2	3	4	—	3	3	2	3	—	—	—	—	—	1	—	—	—	—
16th Sept., ,,	Houxty (Tyne) ...	—	—	—	—	—	—	1	2	1	3	4	2	1	3	—	1	—	—	—	—	—	—	—	—
21st Sept., ,,	Reed	—	—	1	11	6	—	2	—	1	3	4	2	—	2	—	1	—	—	—	1	—	—	1	—
27th Oct., ,,	Bellingham (Reed)...	—	—	—	—	2	—	—	—	3	1	1	2	—	—	—	—	—	—	—	—	—	—	—	—
November, ,,	Bellingham (Reed)...	—	—	—	1	2	2	1	3	2	3	1	—	1	—	—	—	—	—	—	—	—	—	—	—
24th May, 1917...	Houxty (Tyne) ...	—	—	—	1	2	1	2	1	4	3	—	5	5	5	2	—	—	1	1	—	—	—	—	—



THE LAMPREYS OF THE TYNE.

So far, however, we have not been able to obtain mature fish, or to get any information as to the places of spawning, although we have the abundant evidence of the table to show that spawning takes place on a large scale at many places in the Tyne and its tributaries.

I am writing the above in the hope that this note will draw attention to the matter, and that soon the problem as to the adults will be solved.

I add to this paper a diagram showing the results of the measurements which have been made in length to various parts of the body as indicated. It will be seen that there is much variation, a great deal of which is no doubt actual, but some due to the difficulty of measuring such small examples. The general trend of the measurements is in all cases a straight line one, although it is not so consistent as in the case of the measurements of larger fish, long past the metamorphosis. In the table I express the average measurements in terms of the tangents of the angles represented by these lines. Mr. F. Arthur, Maldon, sent me a consignment of fresh water lampreys, *Lampetra fluviatilis*, and these were measured in the same manner, and when converted in the same way into tangents they gave the numbers indicated:—

TYNE LAMPREYS.

Nose.	1st Gill.	7th Gill.	1st Dorsal.	2nd Dorsal.	Anus.
·029	·075	·209	·521	·675	·75

MALDON LAMPREYS.

Nose.	1st Gill.	7th Gill.	1st Dorsal.	2nd Dorsal.	Anus.
·075	·128	·223	·525	·672	·764

It will be seen that so far as the posterior measurements of the body are concerned there is a fair amount of agreement, but the nose and the first gill are very different in position in the adult as compared with the larva. This is probably due to the changes which take place during metamorphosis, and at all events it would not be safe to argue that they are due to the Tyne species being Planer's lamprey. There can be little doubt from the reports that have been made that it is the larger species which frequents the Tyne.

ARE THE MIGRATIONS OF FISH INFLUENCED BY HYDROGRAPHICAL AND FOOD CONDITIONS?

By ALEXANDER MEEK.

Every year the North Atlantic passes through phases of warming and cooling, and the warming is carried to the north-east of the region by the North Atlantic current. Accompanying the increase in temperature there is a conspicuous increase in the quantity of the temporary and complete occupiers of the current, and this increased plankton is carried to and added to that of the north and north-east by the Gulf Stream and the Atlantic current continuous therewith, influencing all the branches. The annual warming is accompanied likewise by a general advance of fish and other forms having the power of movement. Thus it may be said that migrations are related to the general annual change in temperature and the trend of the food supply.

This is so far obvious that it need not be supported by an appeal to the actual results relating to plankton, and the general effect so far as fishes are concerned has been given in my work on the "Migrations of Fish."

On reflexion it is just as obvious that fish as a whole, and only a few of the invertebrates, are capable of making a contranatation. The main body of the pelagic life is annually renewed from the more tropical, proximal regions of the circulatory system. The widely spread holoplanktonic forms are carried into currents which lead them north or south, and their degree of resistance to the cooling influences to which they are gradually introduced is indicated by the successive regions where they disappear. These organisms have no power of contranatation, and only those which gain a return current of a circulatory system manage to effect a retreat.

It is manifest therefore that holoplanktonic and meroplanktonic, non-contranatant organisms have a resistance to

the conditions which is measured by the distribution. The migrations are altogether denatant, and being passive cannot be said to depend upon the physical conditions within the area in which they take place.

It follows that if any of the marine forms are subject to other circumstances than currents in their migrations it must only be those which have the power of contranation, viz., the majority of the fish, some of the Crustacea, and the larger at least of the Cephalopod Mollusca.

Even with regard to some of these it is at once evident that like the plankton their migrations are conditioned only by the circumstances of the area of distribution. If we admit Schmidt's claim that there is only one spawning ground for the eel, we have one school, a larva of which may be drifted to any place between Greenland and Morocco. The migrations therefore are not materially departed from under conditions which vary from arctic to tropical. They depend entirely upon the currents of the North Atlantic. The same is true of the many fishes which in the egg and larval state are drifted from the ocean to the continental shelf and shore.

The question is thus narrowed to a consideration of the species of the banks and shallow water which are divided into a series of schools. So far as distribution is concerned many of these are as widely spread as those which have been considered. The species then are resistant to conditions which may frequently vary from arctic to tropical. It would be difficult to specify the conditions of temperature, salinity and food in the case of such species which regulate the migrations generally, and when we remember that the schools are intimately related we should hesitate even before we conclude that each is modified in its migrations by the differences which could be indicated for the regions where they occur. It is a question also, it must be said, which must not be confounded with that of the relative fitness of the environment in the several parts of the area of distribution, for this only concerns the density of the population, not the migrations.

Because the plaice of the Forth and the Northumberland schools migrate north, as it is plain those of the east coast of Scotland do as a whole, and are therefore different from the plaice

of the southern North Sea the Forth and Northumberland schools have been described as being unrepresentative and insignificant. This is not quite the same thing as attempting to explain the difference with reference to temperature and food, and I venture to suggest that the explanation offered in terms of currents satisfy all the conditions. If it be said, as it has been said, that a species like the plaice migrates from one region to another to obtain a particular food, examples could be given of species the schools of which successively replace one another along the same current route.

The general migrations of the salmon are understood and can be specified, but variation occurs, as I have pointed out. The length of the fresh water period of life varies with the conditions, and even in the same river. The time of the return is also subject to a deal of variation even with reference to the same river, but more especially when different rivers are contrasted. So much is this evident that it is not wise to say that what is true of the Wye, for example, must be true of other rivers. In spite of this variation, however, we would not hesitate in saying that the migrations of the salmon are essentially the same throughout the area of its distribution.

I said in my work that beyond drawing attention to the importance of hydrographical conditions at the limits of distribution and the direct importance of currents I did not find it necessary to introduce hydrographical considerations. I did so because I did not find any proof that they play an important part. I do not wish it to be inferred, however, that I have any desire to depreciate the value of work in this direction ; but, if we are to utilise the immense amount of material already collected, we must consider each problem separately and the factors of importance affecting the others will advance into their proper position.